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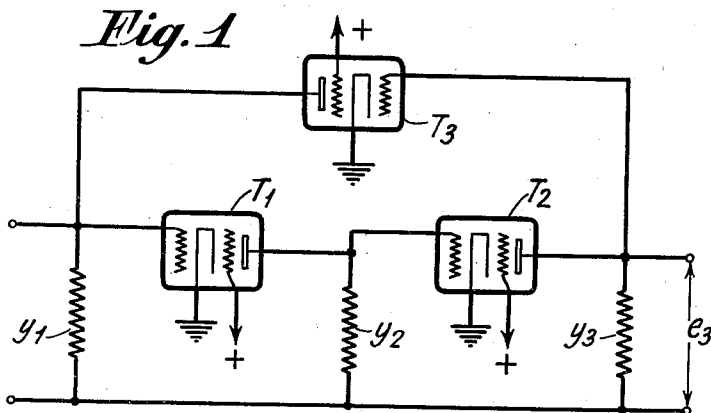
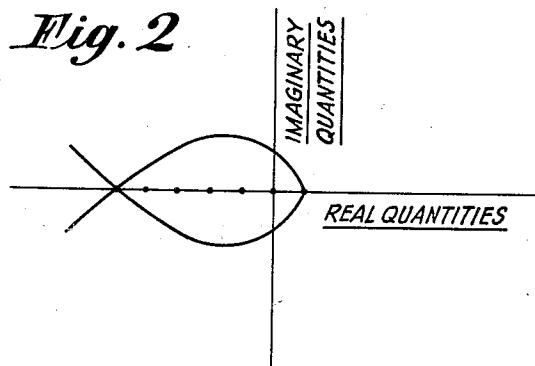
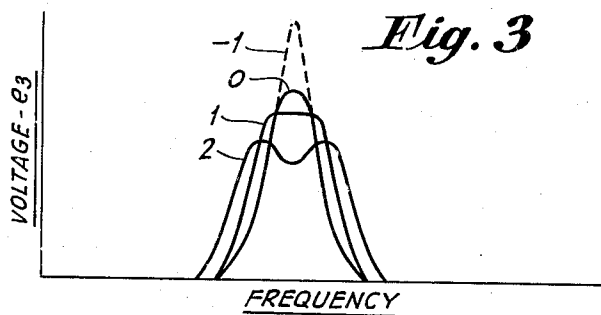
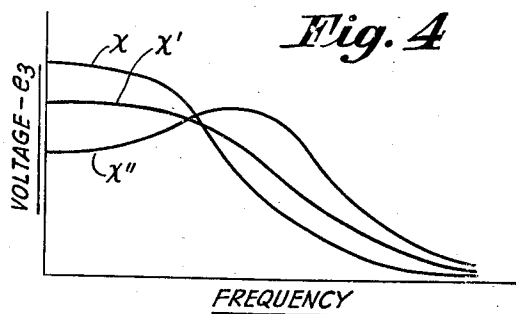
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2,179,956

AUTOMATIC SELECTIVITY CONTROL CIRCUITS

Filed May 19, 1936

2 Sheets-Sheet 1



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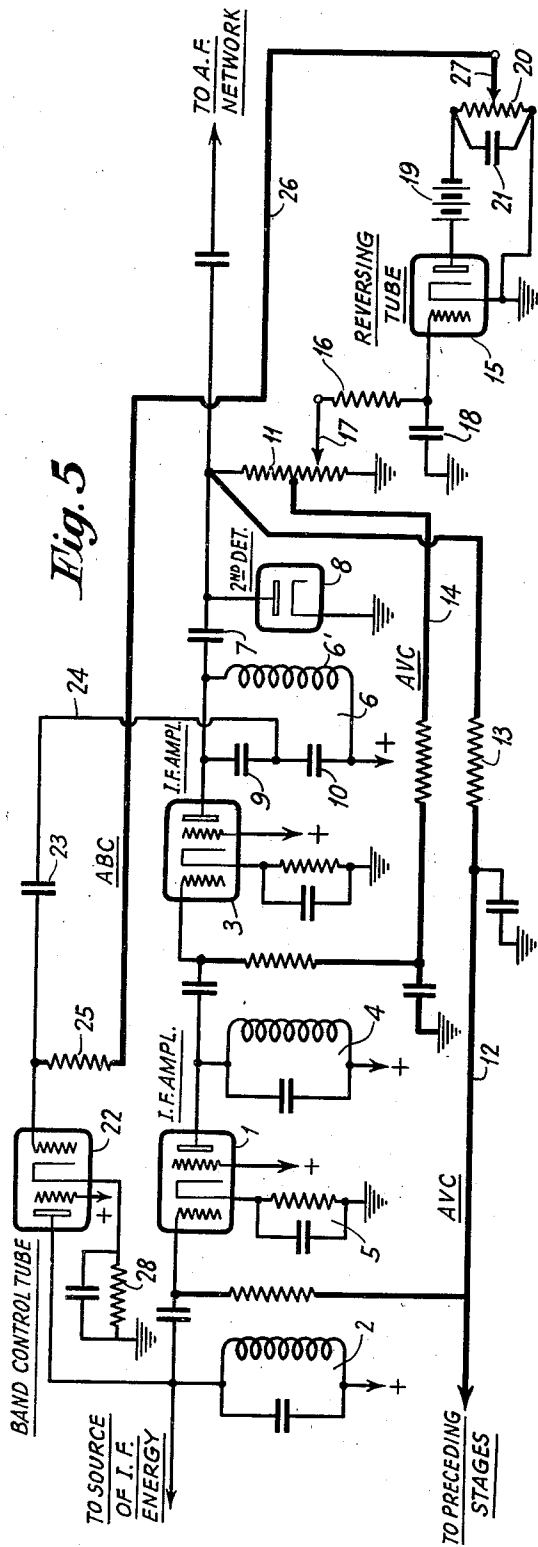
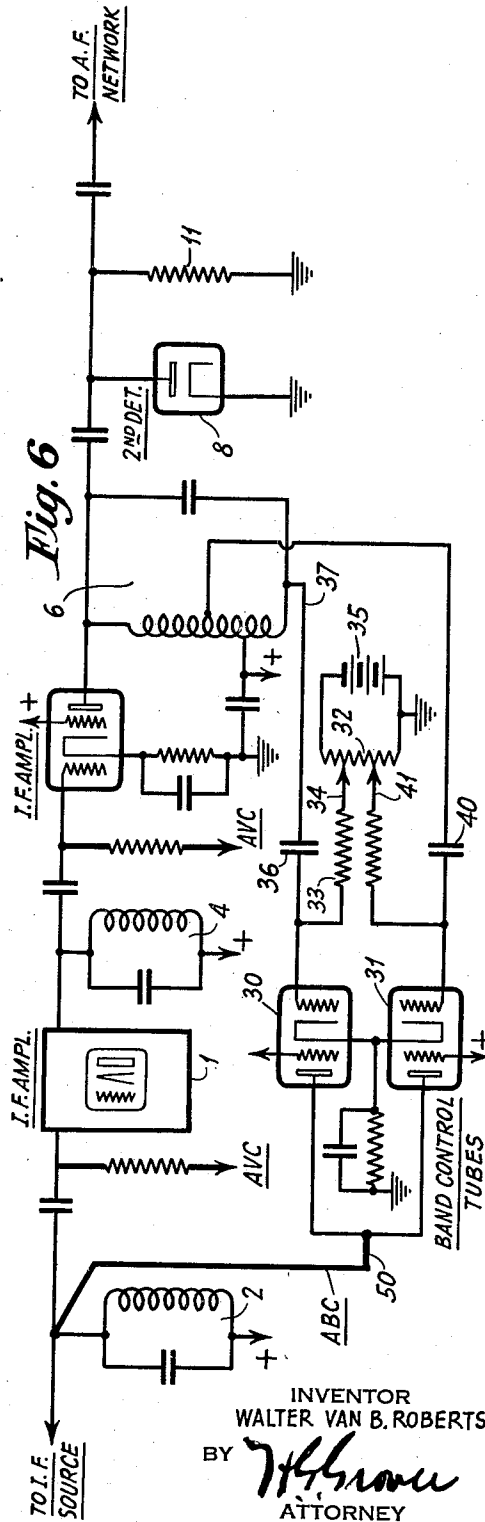
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AUTOMATIC SELECTIVITY CONTROL CIRCUITS

Filed May 19, 1936

2 Sheets-Sheet 2



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2,179,956

AUTOMATIC SELECTIVITY CONTROL
CIRCUITSWalter van B. Roberts, Princeton, N. J., assignor
to Radio Corporation of America, a corpora-
tion of Delaware

Application May 19, 1936, Serial No. 80,496

6 Claims. (Cl. 179—171)

My present invention relates to selectivity control circuits for high frequency wave amplifiers, and more particularly to circuits of an improved and efficient type adapted to regulate the degree of selectivity of cascaded tuned electrical wave amplifiers.

One of the main objects of the invention is to provide a cascaded tube amplifier of high frequency waves wherein the frequency characteristic is subject to the control of an electron discharge tube; the utility of the invention residing in the fact that the width of a band of frequencies amplified, as well as the uniformity of amplification within the band, are controllable by the mere variation of a grid biasing potential subject in turn to the variation in strength of the signals being amplified.

Another important object of the invention is to provide a cascaded tube amplifier of electrical waves, wherein the selectivity of the amplifier is regulated by varying the transconductance of a selectivity control tube in accordance with received wave amplitude variations, and which control tube has its grid excited by voltage derived from a circuit of the amplifier, and its plate connected to an earlier circuit of the amplifier.

Another object of my invention resides in the provision of a signal amplifier whose selectivity may be varied by a pair of opposed tubes coupling an output circuit and an input circuit, and signal responsive means utilized to selectively unbalance the opposed tubes.

Still other objects are to improve generally the efficiency and effectiveness of selectivity control circuits for signal wave amplifiers, and more especially to provide such control circuits in a manner such that they can be readily manufactured and assembled in radio receivers.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawings in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawings:

Fig. 1 shows the fundamental repeater network embodying the invention,

Fig. 2 graphically shows a graphical method used in the designing of the network to secure curves of Fig. 3.

Fig. 3 illustrates various selectivity character-

istic curves obtainable with the network of Fig. 1.

Fig. 4 shows curves similar to those of Fig. 3 for a low pass amplifier network,

Fig. 5 is a circuit diagram of a receiving system embodying the invention,

Fig. 6 shows a modified circuit arrangement.

Referring now to the accompanying drawings, wherein like reference characters in the different figures designate similar circuit elements, attention is first directed to Fig. 1 which shows the fundamental circuit embodying the present invention. This basic circuit comprises cascaded tubes T_1 and T_2 , the input electrodes of tube T_1 including therebetween an admittance y_1 , while the admittance y_2 couples the output electrodes of tube T_1 to the input electrodes of tube T_2 . The admittance y_3 includes the admittance of whatever device may be connected to the output terminals of tube T_2 . The plate side of admittance y_3 is connected to the grid side of admittance y_1 through a tube T_3 . For simplicity's sake there have been omitted the means for supplying operating potentials to these three tubes. If the mutual conductances or transconductances of the amplifier tubes T_1 and T_2 are denoted respectively by the symbols y_{12} and y_{23} and that of the feedback tube T_3 by y_{31} , then it may be shown that the output voltage e_3 produced by unit current entering the system is:

$$\frac{y_{12}y_{23}}{y_1y_2y_3 + y_{12}y_{23}y_{31}}$$

If the imaginary parts of y_1 , y_2 , and y_3 all vanish or are a minimum, at the same frequency and have the same sign, the term $y_1y_2y_3$ will trace a curve in the complex plane, such as is shown in Fig. 2, as the frequency is varied. It will be noted that the curve in Fig. 2 is obtained by plotting "real quantities" against "imaginary quantities". If the admittances y_1 , y_2 , and y_3 do not change sign at any frequency, for example if they are composed of simple capacities shunted by resistances, then only half of the curve will be traced. In any case, however, since the mutual conductances of the tubes are constant, the absolute value of the denominator of the expression for e_3 at any frequency will be given by the distance from the point on the curve of Fig. 2 corresponding to that frequency, to a point on the axis of real quantities to the left of the origin by a distance equal to the product of the three tube mutual conductances.

Since the numerator for the expression for e_3 is constant, the voltage e_3 will at any frequency be proportional to the reciprocal of the aforesaid

absolute value. By assuming various frequencies, a plot of e_3 against frequency may be obtained. The reason for using the curve of Fig. 2 is that it is easy to pick out by eye a suitable point from which distances to the curve are fairly constant over a range of frequencies, or vary with frequency in a desired manner. Choosing such a point determines the required value of the product $y_{12}y_{23}y_{31}$. It has been found, for example, in the case where y_1 , y_2 and y_3 are the admittances of similar anti-resonant circuits, the selectivity characteristic may be varied from a sharply peaked curve to a broader flat top curve, and finally to a still broader curve with pronounced "double humps". This can be done by gradually increasing y_{31} from zero up to a value which depends upon the excellence of the circuits and the mutual conductances of the other tubes.

Fig. 3 shows in qualitative manner such a set of curves. This series of curves is obtained by plotting e_3 against "frequency". The curves in Fig. 3, also, include an additional curve in dotted lines to which reference will be made at a later point.

Fig. 4 shows similar curves for a low pass amplifier, wherein y_1 , y_2 and y_3 each consist of a conductance shunted by a condenser. For a high pass amplifier, the admittances would, of course, include inductances instead of condensers. The three curves shown in Fig. 4, represent the following characteristics:

X is a curve of amplifier gain against frequency when $y_{31} = 0$

X' is a similar curve drawn for a small value of y_{31}

X'' is a similar curve for a larger value of y_{31}

In Fig. 5 there is shown a portion of the I. F. transmission network of a superheterodyne receiver, which embodies an automatic selectivity control arrangement according to my present invention. The I. F. network is fed with I. F. energy from the usual first detector circuit. The latter is tunable over the operating frequency range, say 500 to 1500 kc. Those skilled in the art will understand that in addition to the first detector there will be employed a tunable radio frequency amplifier for feeding signals to the first detector. The usual tunable local oscillator network is employed for feeding the required local oscillations to the first detector; the I. F. energy is produced in the output circuit of the first detector.

The I. F. amplifier tube 1 has its input electrodes coupled across the I. F. tuned circuit 2. A second I. F. amplifier tube 3 is coupled to the output electrodes of the amplifier 1 through an I. F. resonant circuit 4, and it will be understood that each of these amplifiers includes the usual signal grid biasing network 5. The demodulator, or second detector 8 has its anode coupled to the high alternating potential side of the I. F. resonant circuit 6 through a coupling condenser 7. The cathode of the diode demodulator 8 is grounded. The I. F. circuit 6 includes the condensers 9 and 10 arranged in series, and both are connected in shunt across the coil 6'. The demodulated output of the diode 8 has its audio component impressed upon any desired type of audio frequency utilization network, and the latter may include one, or more, stages of audio frequency amplification followed by reproducer.

The diode load resistor 11 has the direct current voltage developed thereacross impressed upon the control networks denoted in Fig. 5 by the symbols "AVC" and "ABC". The first of

these control networks is the automatic volume control, whereas the second of the control networks is the automatic band width control arrangement. The AVC arrangement includes the lead 12 connected between the anode side of load resistor 11 and the grid circuit of the I. F. amplifier tube 1. The usual filter network 13 is arranged in the lead 12, and the function of the filter network is to eliminate any pulsating components in the control voltage which is fed to the amplifier 1. As noted in Fig. 5, the control bias voltage transmitted through lead 12 may be impressed upon one, or more, of the amplifiers preceding the tube 1. The automatic gain control voltage for the amplifier 3 is derived from an intermediate point on resistor 11, and to accomplish this the lead 14 is connected from an intermediate point on resistor 11, through a filter network, to the grid of the amplifier 3. This enables the gain of preceding amplifiers to be varied at a faster rate than that of amplifier 3.

The automatic selectivity control arrangement, or ABC circuit, comprises a tube 15, functioning as a voltage polarity reversing tube, which has its control grid connected to a desired point on load resistor 11. It will be noted that the grid of tube 15 is connected to resistor 11 through a path which includes the resistor 16 and the adjustable tap 17, the grid side of resistor 16 being connected to ground through the condenser 18. The space current path of tube 15 includes the positive voltage source 19 and the resistor 20, the latter being by-passed by condenser 21. The I. F. band width control tube is designated by the numeral 22, and has its anode connected to the high alternating potential side of the input circuit 2.

The control grid of tube 22 is connected to an alternating current path and a direct current voltage path. The alternating current path includes the condenser 23 and lead 24, the latter being connected to the junction of condensers 9 and 10. The direct current path to the grid of tube 22 comprises the resistor 25, lead 26 and adjustable tap 27; the latter being adapted for connection to any desired point along the resistor 20, it being noted that the cathode side of resistor 20 is grounded. The control tube 22 includes in its cathode circuit the usual grid biasing network 28, and it will be understood that the various electrodes of the tubes shown in Fig. 5 may be energized from a common direct current voltage supply source, as those skilled in the art fully known.

In considering the operation of the circuit arrangement shown in Fig. 5 it will be observed that there is shown here a cascaded I. F. amplifier having its selectivity characteristic controlled in accordance with received carrier amplitude. The grid of the selectivity control tube 22 is tapped on a point on the third anti-resonant circuit 6 that has only a small fraction of the total voltage. This is done to minimize any reactive feed-back through unavoidable grid-plate capacity of the control tube 22. The output of the cascaded I. F. amplifier is rectified by the diode 8, and the filtered direct current voltage of the rectifier is impressed on the signal grids of the amplifiers 1 and 3, as well as preceding transmission tubes, in the usual manner for AVC action.

A portion of the AVC potential is impressed on the reversing tube 15 to create the ABC potential which is applied to the grid of the tube 22. When signals are of less than a predetermined intensity there is developed an ABC voltage of sufficient magnitude to maintain the tube 22 inoperative and the selectivity sharp; this corresponds to the

condition when $y_{31}=0$. When the signal amplitude increases to a moderate level the AVC reduces the plate current of the reversing tube, and hence the ABC voltage, and the control tube 22 begins to function, and broadens the I. F. selectivity curve. This broadening action increases as the signal amplitude increases.

For best over-all fidelity, the amount of ABC voltage should be adjusted so that on very strong signals, when high fidelity is desirable, the characteristic becomes double-humped to whatever extent is required to compensate for undesirably sharp selectivity in the other circuits of the receiver. If the station selected is strong enough to produce automatic high fidelity, but for any reason high fidelity reception is not desired, the slider 17 connected to the grid of the reversing tube 15 may be moved manually toward ground. This cuts off the action of the control tube 22.

It will be observed that the reversing tube 15 should contribute sufficient amplification so that as the AVC voltage increases, the mutual conductance of the control tube 22 (y_{31}) will increase more rapidly than the product $y_{12}y_{23}$ of the conductances of the other tube decreases, in order that the product $y_{12}y_{23}y_{31}$ shall increase as the AVC voltage increases.

Fig. 6 shows an arrangement using two control tubes 30 and 31 in opposition so that the net effect is to control y_{31} both in magnitude and sign. One of these tubes is excited by a voltage which is in phase with the voltage of the third tuned circuit 6, and the other tube is excited by an opposite, and preferably equal, voltage. The biases for the two tubes are separately and manually adjustable. This is accomplished by connecting the grid of band control tube 30 to a resistor 32, through a path including resistor 33 and adjustable tap 34. The voltage source 35 is connected in shunt with resistor 32, and the positive terminal of source 35 is grounded. The grid of tube 30 is connected through the coupling condenser 36 and lead 37 to the low alternating potential side of the third tuned circuit 6. The grid of control tube 31 is connected through coupling condenser 40 to an intermediate point on the coil of tuned circuit 6, and the adjustable tap 41 connects the grid of tube 31 to a desired point on the bias supply resistor 32. The plates of tubes 30 and 31 are connected in common, and through lead 50 to the high alternating potential side of the input circuit 2.

When the biases of tubes 30 and 31 are so adjusted that the plate currents are equal and opposite, the effective y_{31} of the combination is zero, and a selectivity curve such as curve zero of Fig. 3 is obtained. When the system is unbalanced in one direction the effective y_{31} is positive, and selectivity curves such as 1 and 2 of Fig. 3 result. When the unbalance is in the opposite sense, however, the effective y_{31} becomes negative, and abnormally sharp response curves are obtained as illustrated by curve -1 of Fig. 3. Curves zero, 1 and 2 may be secured with the circuit arrangement of Fig. 5, but curve -1 can be secured only with the Fig. 6 circuit.

It will be realized that transformer, or auto-transformer, couplings may be substituted in the circuit arrangements of Figs. 5 and 6 without any change in the results. It will be observed that the difference between the arrangement in Fig. 6 and that shown in Fig. 5 resides in the fact that in the former the selectivity is manually controlled by sliders 34 and 41. In Fig. 5, it is the variation in direct current voltage de-

pendent on the carrier amplitude change, which varies the selectivity characteristic of the cascaded amplifier.

While I have indicated and described only several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications in the circuit arrangements may be used, as well as in the apparatus employed, without departing from the scope of my invention as set forth in the appended claims.

What I claim is:

1. A radio receiver comprising at least three like tuned resonant circuits arranged in cascade, a selectivity control tube including at least a grid, anode and cathode, the third of said resonant circuits including a pair of reactances in series relation thereacross, a signal carrier connection between the tube grid and the junction of said reactances, the anode and cathode of said control tube being connected across the first of said resonant circuits, the impedance of the latter providing the sole output load of the control tube whereby carrier voltage fed back from the third circuit to the first circuit varies with frequency in accordance with the impedance of the said first circuit, and means for varying the gain of the control tube thereby to vary the magnitude of the carrier voltage fed back to said first circuit.

2. In a receiver as defined in claim 1, said pair of reactances consisting of condensers, and automatic gain control means for varying the carrier transmission through said cascaded circuits.

3. In combination with a signal amplifier network including at least three cascaded tuned circuits, means for controlling the selectivity of the amplifier in accordance with signals passing therethrough, said means comprising a tube having its grid connected to the third tuned circuit of the amplifier, and the said grid being excited by voltage derived from said third circuit, the plate of said tube being connected to the high alternating current potential side of the first tuned circuit of said amplifier whereby the signal voltage fed back through the tube varies with frequency in accordance with the impedance of the said first tuned circuit, and means for varying the bias of said tube with voltage derived from rectification of signal energy traversing the amplifier.

4. An amplifier of controllable frequency characteristics which comprises three shunt admittance elements and two one-way repeater tubes, said elements being resonant to a common frequency and being in cascade, the second element coupling the two repeater tubes in cascade, a third one-way repeater tube having its grid maintained at a fraction of the voltage across the third admittance, its plate being connected to a point of the first element having an alternating current potential whose ratio to the potential on the grid of the first of the two repeaters is a fixed real quantity, and means for varying the transconductance of one of said repeaters.

5. A selective system adapted to yield a selectivity characteristic adjustable as to width comprising a first resonant circuit, a first tube having its grid energized directly from said first resonant circuit, a second resonant circuit connected effectively in the plate circuit of said first tube, a second tube having its grid directly energized from said second resonant circuit, a third reso-

nant circuit effectively connected in the plate circuit of said second tube, a third tube having its grid directly energized from said third resonant circuit and its plate connected to a point on said first resonant circuit having a radio frequency potential comparable with the radio frequency potential of the first tube grid in the absence of current in the third tube, means for impressing signal current on said first resonant circuit, means for utilizing voltages existing across said third resonant circuit, and means for varying the mutual conductance of said third tube whereby the overall selectivity of the system may be adjusted from a relatively sharp single peaked curve to a relatively broad and substantially flat topped curve by varying said mutual conductance from zero up to a value less than the maximum possible mutual conductance of said third tube.

6. In combination, in a radio frequency signal amplifier network, at least two amplifier tubes, a

resonant circuit coupling the tubes in cascade, a selectivity control tube, means for maintaining the input electrode of the control tube at a radio frequency potential that is a real positive fraction of the radio frequency potential at the output electrode of the second of the amplifier tubes, means for connecting the control tube output electrode to a point which is at a radio frequency potential substantially equal to the radio frequency potential of the input electrode of the first amplifier tube multiplied by a real positive quantity, means for controlling the transconductance of the control tube in accordance with the strength of the signal carrier, and at least one additional resonant circuit electrically connected with one of said tubes and arranged with respect to said first resonant circuit to provide for successive transfer of signal currents through both of said resonant circuits.

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